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(54) **Improved polymer composition and process for production vulcanizates thereof**

(57) A polymer composition useful to produce a vulcanizate having improved hot air aging properties is described. The polymer composition includes two components. The first component is a polymer having a main polymer chain derived from: (i) at least 30% by weight of a first monomer which introduces at least one of a secondary carbon and a tertiary carbon to the backbone, and (ii) from 0 to 70% by weight of at least one other monomer. The second component is a salt of a strong base and a weak acid, the salt comprising a metal selected from Group 1 of the Periodic Table of Elements (according to IUPAC 1985). The polymer compositions may further comprise optional ingredients such as one or more of: a vulcanization system, a poly-carbodiimide and a filler.

Description

[0001] The present invention relates to an improved polymer composition and to a process for producing vulcanizates thereof. More particularly, in one of its aspects, the present invention relates to a rubber composition having improved hot air aging characteristics. In yet another of its aspects, the present invention relates to a method for improving the hot air aging characteristics of a polymer vulcanizate.

[0002] The effects of oxidizing conditions on vulcanizates obtained from polymers have long been a problem, particularly in applications where the vulcanizates are exposed to elevated temperatures for extended periods of time. A variety of approaches have been developed in the art in an attempt to solve this problem.

[0003] It is known that, in compositions comprising polymers based on a monomer which results in a polymer backbone having repeating units including at least one carbon-hydrogen bond (i.e., repeating units have a secondary or tertiary carbon), thermooxidative attack initiated by a radical mechanism is very relevant in the deterioration of the useful properties of such compositions during oxidative aging. See, for example:

1. S. Bhattacharjee, A.K. Bhowmick and B.N. Avasthi: "Degradation of Hydrogenated Nitrile Rubber"; Polymer Degradation and Stability, 31, 71-87 (1991); and

2. K.C. Smith and B.S. Tripathy: "HNBR and Long Term Serviceability in Modern Automotive Lubricants"; Rubber World, 217 (5), 28-45 (1998).

[0004] During the oxidative degradation process located at such carbon-hydrogen bonds among other substances hydroperoxide, alcohol, keto, aldehyde and carboxylic acid functionalities are introduced into the main polymer chain (also referred to as the "polymer backbone"). This often results in polymer chain scission or crosslinking reactions which lead to changes and deterioration of the useful properties of the composition such as tensile strength, hardness, static and dynamic stiffness, elongation at break, compression set etc.

[0005] Thermo-oxidative reactions as described above are autocatalytic chain reactions, where reactive radicals are regenerated within the reaction cascade. It is known in the art to add substances (often called antioxidants) to polymer compositions to facilitate destruction of radicals or reactive intermediates produced during the polymer oxidation process (such as hydroperoxides) thereby improving the oxidative heat aging resistance of the compositions.

[0006] Non-limiting examples of useful antioxidants may be selected from the group consisting of hindered phenols, p-phenylene diamine derivatives, quinoline derivatives and mixtures thereof. Phosphites, dithiophosphates, dithiocarbamates and mercaptoimidazole derivatives are also commonly employed as antioxidants. These substances often either donate hydrogen atoms to other radicals and, during the polymer oxidation process, they:

35 (i) are converted into unreactive radicals themselves;

35 (ii) block certain reactions which lead to the production of free radicals (e.g., heavy metal trapping); and/or

40 (iii) favour reactions of reactive intermediates leading to the production of non-radical reaction products (e.g., hydroperoxide decomposer).

[0007] In many cases, to achieve their desired properties, rubber compositions are cured with a crosslinking system conventionally selected from the group consisting of sulfur, sulfur donor compounds and/or a peroxide system. It is known in the art that interference of antioxidants with cure systems often presents a major problem. Reaction of antioxidants with cure systems may lead to significant deterioration of the desired state-of-cure of the composition. Complete or partial depletion of the antioxidant in the composition during cure is likely to occur when the cure system generates radicals during vulcanization.

[0008] Accordingly, there remains a need in the art to improve antioxidant systems in a way that they offer desirable oxidative heat aging protection without deleterious interference with cure systems and, importantly, without partial or complete loss of antioxidant activity due to chemical reaction at the vulcanization stage.

[0009] It is an object of the present invention to obviate or mitigate at least one of the above-mentioned disadvantages of the prior art.

[0010] It is another object of the present invention to provide a novel polymer composition.

[0011] It is yet another object of the present invention to provide a novel process for producing a polymer vulcanizate.

[0012] It is yet another object of the present invention to provide a novel method for improving the hot air aging characteristics of a polymer vulcanizate.

[0013] Accordingly, in one of its aspects, the present invention provides a polymer composition comprising:

a polymer having a main polymer chain derived from: (i) at least 30% by weight of a first monomer which introduces at least one of a secondary carbon and a tertiary carbon to the main polymer chain, and (ii) in the range of from 0 to 70% by weight of at least one other monomer; and

5 a salt of a strong base and a weak acid, the salt comprising a metal selected from Group 1 of the Periodic Table of Elements (according to IUPAC 1985).

[0014] In another of its aspects, the present invention provides a method for improving the hot air aging characteristics of a polymer comprising the steps of:

10 admixing: (A) a polymer having a main polymer chain derived from: (i) at least 30% by weight of a first monomer which introduces at least one of a secondary carbon and a tertiary carbon to the main polymer chain, and (ii) in the range of from 0 to 70% by weight of at least one other monomer; and (B) a salt of a strong base and a weak acid, the salt comprising a metal selected from Group 1 of the Periodic Table of Elements (according to IUPAC 1985); and

15 vulcanizing the polymer composition.

[0015] Thus, it has been discovered that incorporation of a particular additive in a polymer composition results in a surprising and unexpected improvement in the oxidative heat aging resistance of the composition while obviating or mitigating a deleterious effect on the action of a vulcanization system used to cure the polymer composition. The particular additive is a salt of a strong base and a weak acid, the salt comprising a metal selected from Group 1 of the Periodic Table of Elements (according to IUPAC 1985).

[0016] The present polymer composition is useful to produce a vulcanizate having improved physical properties. 25 More specifically, the vulcanizates produced from the present polymer composition may be characterized by improvement (i.e., in comparison to a vulcanizate produced without the additive) in one or more of the following properties:

hot air aging;
hot fluid aging;
30 aged compression set;
aged dynamic elastic modulus (EN);
aged dynamic viscous modulus (EO);
aged static modulus; and
aged low temperature properties.

35 [0017] Even more specifically, the vulcanizates produced from the present polymer composition have improved hot air aging. This results in a slowing of polymer deterioration and can be accompanied by improvement in one or more of the other properties listed above.

[0018] Embodiments of the present invention will be described with reference to the accompanying Figure in which 40 there is illustrated comparative hot air aging characteristics between polymer vulcanizates of the invention and a conventional polymer vulcanizate.

[0019] Thus, the present polymer composition comprises two components.

[0020] The first component of the present polymer composition is a polymer having a main polymer chain derived 45 from: (i) at least 30% by weight of a first monomer which introduces at least one of a secondary carbon and a tertiary carbon to the main polymer chain, and (ii) in the range of from 0 to 70% by weight of at least one other monomer.

[0021] As used throughout this specification, the term "polymer" is intended to have a broad meaning and is meant to encompass any polymer having a main polymer chain which comprises at least one secondary or tertiary carbon. Those of skill in the art will understand that a secondary carbon is a carbon atom having two hydrogen atoms bonded to it while a tertiary carbon is a carbon atom having one hydrogen atom bonded to it. The polymer may be a homopolymer, a copolymer, a terpolymer and the like. Also, it is possible to use a mixture of polymers provided at least one polymer in the mixture has the polymer main chain properties described above.

[0022] The polymer suitable for use herein may be an elastomer (e.g., a hydrocarbon rubber), a graft polymer or block polymer of monomers having at least one ethylenically unsaturated bond and polymerizable through this unsaturation, and the like.

55 [0023] Elastomers are well known to those of skill in the art. Non-limiting examples of suitable elastomers may be selected from the group consisting of natural rubber (NR), cis-1,4-polyisoprene rubber (IR), polybutadiene rubber (BR), styrene-butadiene rubber (SBR), acrylonitrile-butadiene rubber (NBR), hydrogenated acrylonitrilebutadiene rubber (HNBR), other HNBR copolymers, HNBR terpolymers (including hydrogenated acrylonitrile, butadiene, unsaturated

carboxylic acid ester terpolymers), ethylene-propylene monomer rubber (EPM), ethylene-propylene-diene monomer rubber (EPDM), ethylene-vinyl acetate rubber (EVM) and the like.

[0024] Of course, subject to compatibility, mixtures of two or more of any of the foregoing polymers may be used herein.

5 [0025] Preferably, the polymer used in the present polymer composition is an elastomer. More preferably, the elastomer is selected from the group consisting of:

ethylene-propylene copolymer;
ethylene-propylene-non conjugated diene terpolymer;
10 ethylene vinyl acetate copolymer;
unsaturated nitrile/conjugated diene copolymer;
hydrogenated unsaturated nitrile/conjugated diene copolymer;
unsaturated nitrile/conjugated diene/ethylenically unsaturated monomer terpolymer;
hydrogenated unsaturated nitrile/conjugated diene/ethylenically unsaturated monomer terpolymer;
15 styrene/conjugated diene copolymer;
hydrogenated styrene/conjugated diene copolymer;
polyisoprene
natural rubber;
polybutadiene;
20 and mixtures thereof.

[0026] These elastomers are well known in the art and are readily available to or may be produced by a person of skill in the art.

25 [0027] It is known in the art that elastomers, such as the preferred elastomers listed above, may contain small amounts of antioxidants (typically less than 0.5 parts by weight), which are added during the manufacturing process of the polymers mainly to increase their shelf life.

[0028] The second component is a salt of a strong base and a weak acid, the salt comprising a metal selected from Group 1 of the Periodic Table of Elements (according to IUPAC 1985).

30 [0029] Non-limiting examples of the weak acids useful in the production of the above-mentioned salt may be selected from the group consisting of carbonic acid, C₁-C₅₀ fatty acids, ethylene diamine tetra(acetic acid), phosphoric acid and mixtures thereof. The preferred salt for use in the present polymer composition may be selected from the group consisting of sodium carbonate, potassium carbonate, sodium stearate, potassium stearate and mixtures thereof. The most preferred salt for use in the present polymer composition is sodium carbonate. Preferably, the salt is present in the polymer composition in an amount in the range of from 0.5 to 50 parts by weight, preferably in the range of from 1 to 20 parts by weight, most preferably in the range of from 2.5 to 7.5 parts by weight.

35 [0030] Optionally, the present polymer composition further comprises a carbodiimide, a polycarbodiimide or mixtures thereof. The preferred carbodiimide is available commercially under the tradenames Rhenogram™ P50 and Stabaxol™ P. This ingredient may be used in the present polymer composition in an amount in the range of from 0 to 15 parts by weight, more preferably in the range of from 0 to 10 parts by weight, even more preferably in the range of from 40 0 to 2 parts by weight.

[0031] Preferably, the present polymer composition further comprises a vulcanization system. The choice and amount of vulcanization system depends on a number of factors, including the choice of polymer component, the intended application of the vulcanizate and the like.

45 [0032] Preferably, the vulcanization system is selected from the group consisting of sulfur, a sulfur donor cure system and a peroxide compound.

[0033] Non-limiting examples of useful sulfur donor cure systems may be selected from the group consisting of thiuram compounds (such as tetramethyl thiuram disulfide, tetraethyl thiuram disulfide, tetramethyl thiuram monosulfide and the like), and morpholine compounds (such as morpholine disulfide and the like). Further, it is possible to use dithiobis(caprolactam) in a sulfur donor cure system. The useful amount of sulfur or the sulfur-donating compound preferably is in the range of from 0.1 to 5 parts by weight.

50 [0034] As is known in the art, when the vulcanization agent is sulfur or a sulfur donor cure system, it is conventional to include a vulcanization accelerator. Non-limiting examples of useful vulcanization accelerators may be selected from the group consisting of thiazole compounds (such as 2-mercaptopbenzothiazole [MBT], dithiobis mercaptobenzothiazole [MBTS] and the like), sulfenamide compounds (such as N-cyclohexyl-2-benzothiazyl sulfenamide and the like), dithiocarbamates (such as zinc-dibutyl dithiocarbamate) and mixtures thereof. Such vulcanization accelerators are preferably used in an amount in the range of 0.5 to 5 parts by weight. Further, it is known to use metal oxides such as zinc oxide, magnesium oxide and the like, as well as acids such as stearic acid, cure activators in these vulcanization systems.

[0035] As stated above, the vulcanization system may comprise a peroxide compound, preferably an organic per-

oxide. Non-limiting examples of useful organic peroxide compounds may be selected from the group consisting of dicumyl peroxide, benzoyl peroxide, 2,5-dimethyl-2,5-di(t-butylperoxy)-hexane, 2,2'-bis(tert-butylperoxydiisopropyl benzene, t-butyl peroxybenzoate and the like. Other useful peroxide compounds will be immediately apparent to those of skill in the art. The organic peroxide used is preferably in the range of from 0.5 to 15 parts by weight, preferably in the range of from 2 to 8 parts by weight.

[0036] When the vulcanization system comprises an organic peroxide, it is known to include a coagent together therewith. Preferably, the coagent acts as a polyfunctional monomer. Non-limiting examples of suitable such coagents may be selected from the group consisting of triallyl cyanurate, triallyl isocyanurate, trimethylolpropane trimethacrylate, ethylene dimethacrylate, toluylene bismaleimide and the like. Preferably, the coagent is used in an amount in the range of from 1 to 10 parts by weight.

[0037] Preferably, the present polymer composition comprises a filler. The nature of the filler is not particularly restricted and the choice of suitable fillers is within the purview of a person skilled in the art. Non-limiting examples of suitable fillers include carbon black (e.g., FEF, MT, GPF and SRF), clays, titanium dioxide, silica fillers (with or without unsaturated silanes), calcium carbonate, talc (magnesium silicate) and the like. The amount of filler is conventional. Preferably, the filler is present in an amount in the range of from 20 to 200 parts by weight per hundred parts by weight of the polymer. More preferably, the filler is present in an amount in the range of from 20 to 100 parts by weight per hundred parts by weight of the polymer. Most preferably, the filler is present in an amount in the range of from 40 to 80 parts by weight per hundred parts by weight of the polymer.

[0038] In the present process, the polymer, the filler (as noted above, the use of a filler is optional), the additive and the vulcanization system may be admixed in any conventional manner known to the art. For example, this polymer composition may be admixed on a two-roll rubber mill or an internal mixer.

[0039] Thus, the polymer composition is mixed in a conventional manner and the temperature thereof during mixing is maintained as is known in the art.

[0040] In the present process, it is preferred to heat the polymer composition to form vulcanizates using conventional procedures well known in the art. Preferably, the polymer composition is heated to a temperature in the range of from 130° to 200°C, preferably from 140° to 190°C, more preferably from 150° to 180°C.

[0041] Preferably, the heating is conducted for a period of in the range of from 1 minute to 15 hours, more preferably from 5 minutes to 30 minutes. Various methods of post cure, as is well known in the art, may be used to complete the vulcanization step.

[0042] In many cases, the present polymer composition will further comprise an antioxidant. Non-limiting examples of useful antioxidant compounds may be selected from the group consisting of alkylated diphenylamines (such as styrenated diphenyl amine and the like), quinoline-type stabilizers (such as 2,2,4-trimethyl-1,2-dihydroquinoline polymer and the like), mercaptobenzimidazoles (such as zinc salts of methylmercaptobenzimidazole) and the like. With sulfur-containing vulcanization systems, phenylene diamine derivatives (such as N-phenyl-N'-isopropyl-p-phenylene diamine and the like), as well as sterically hindered phenols (such as butylated hydroxy toluene and the like) can also be used. The amount of antioxidant used is within the purview of a person skilled in the art.

[0043] Other conventional compounding ingredients may also be included by mixing with the copolymer in the conventional manner. Such other compounding ingredients are used for their conventional purposes and include activators such as zinc oxide and magnesium oxide; stearic acid; plasticizers; processing aids; reinforcing agents; promoters and retarders in amounts well known in the art.

[0044] During production of the vulcanizate from the polymer composition, the vulcanizate may be formed into a composite with, for example, polyester fiber, nylon fiber aramide fiber, glass fiber, carbon fiber, steel fiber cords or fabrics and the like, whereby a desired rubber composite product is obtained.

[0045] Embodiments of the present invention will be illustrated with reference to the following Examples which are provided for illustrative purposes and should not be used to limit the scope of the invention. Unless otherwise stated, all parts in the Examples are parts by weight.

[0046] Further, in the Examples, the materials used include the following:

- 50 Therban™ A3907: a hydrogenated nitrile butadiene polymer commercially available from Bayer Inc.;
- Therban™ A3407: a hydrogenated nitrile butadiene polymer commercially available from Bayer Inc.;
- Therban™ VPKA8798: a hydrogenated acrylonitrile, butadiene, unsaturated carboxylic acid ester terpolymer commercially available from Bayer Inc.;
- Buna™ EP T2070: a copolymer of ethylene and propylene commercially available from Bayer Inc.;
- Buna™ EP T6850: a terpolymer of ethylene, propylene and 5-ethylidene-2-norbornene, commercially available from Bayer Inc.;
- Levapren™ Lev 500HV: ethylene vinyl acetate commercially available from Bayer Inc.;
- Natural rubber (pale crepe);
- Dynamar™ RC5251Q: sodium carbonate commercially available from Dyneon;

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Rhenogran™ P50: polycarbodiimide commercially available from Rhein Chemie Corporation;
Maglite™ D: magnesium oxide, activator, commercially available from CP Hall; Stearic acid, Emersol™ 132NF: dispersing agent;
5 Zinc oxide: activator;
Carbon black, N660 Sterling-V: filler
Armeen™ 18D: 1-octadecanamine commercially available from Akzo Nobel Chemicals;
Naugard™ 445: antioxidant commercially available from UniRoyal Chemicals;
Vulkanox™ OCD/SG: antidegradant commercially available from Bayer Inc.;
10 Vulkanox™ ZMB-2/C5: antidegradant commercially available from Bayer Inc.;
Sunpar™ 2280: paraffinic oil commercially available from Sun Refining;
Plasthall TOTM: plasticizer commercially available from CP Hall;
Diak #7: triallyl isocyanate, cross-linking activator, commercially available from E.I. DuPont; and
Vulcup™ 40KE: 2,2'-bis(tert-butylperoxy diisopropylbenzene commercially available from Hercules;
15 Sulfur: vulcanizing agent;
Sulfasan DTDM: 4,4'-dithiodimorpholine commercially available from FLEXSYS America; and
Vulkacit™ Thiuram/C: tetramethyl thiuram disulfide vulcanizing agent commercially available from Bayer Inc.

EXAMPLES 1-4

20 [0047] The following procedure was used for each of Examples 1-4. The polymer composition used in Examples 1-4 are shown in Table 1.
[0048] As will be apparent to those of skill in the art, the polymer composition of Examples 1 and 3 contained no special additive. Accordingly, Examples 1 and 3 are provided for comparison purposes only and are outside the scope of the present invention. As will be further apparent to those of skill in the art Examples 1 and 2 relate to a vulcanizate 25 derived using a peroxide curing system whereas those of Examples 3 and 4 relate to vulcanizate derived using a sulfur donor curing system.
[0049] The components of the polymer composition were mixed in a Banbury mixer using conventional techniques. The polymer composition was vulcanized at 170°C for a period of 15, 12, 8 and 8 minutes, respectively, for each of Examples 1-4.
30 [0050] The elongation at break of the vulcanizates was determined in accordance with ASTM D412-80. Hardness properties were determined using a Type A Shore durometer in accordance with ASTM-D2240-81. The properties of the vulcanizates of Examples 1 and 2 are reported in Table 2 while those of Examples 3 and 4 are reported in Table 3.
[0051] The properties of the vulcanizates reported in Tables 2 and 3 clearly illustrate the superiority of the hot air aging characteristics of the vulcanizates of Examples 2 and 4 (special additive used) when compared to the vulcanizate 35 of Examples 1 and 3 (special additive not used), respectively. This translates into significant practical advantages in many of the conventional applications of the vulcanizates.

EXAMPLES 5-8

40 [0052] The methodology used in Examples 1-4 was repeated in these Examples using the polymer compositions reported in Table 4. The polymer composition was vulcanized at 170°C for a period of 18, 18, 25 and 26 minutes, respectively, for each of Examples 5-8.
[0053] As will be apparent to those of skill in the art, the polymer composition of Examples 5 and 7 contained no special additive. Accordingly, Examples 5 and 7 are provided for comparison purposes only and are outside the scope 45 of the present invention. As will be further apparent to those of skill in the art, Examples 5 and 6 relate to a vulcanizate derived from EP copolymer whereas those of Examples 7 and 8 relate to a vulcanizate derived from EPDM terpolymer.
[0054] Various physical properties of the vulcanizates were determined as described in Examples 1-4. These properties are reported in Table 4 for Examples 5 and 6, and in Table 5 for Examples 7 and 8.
[0055] The properties of the vulcanizates reported in Tables 5 and 6 clearly illustrate the superiority of the hot air 50 aging characteristics of the vulcanizates of Examples 6 and 8 (special additive used) when compared to the vulcanizate of Examples 5 and 7 (special additive not used), respectively. This translates into significant practical advantages in many of the conventional applications of the vulcanizates.

EXAMPLES 9-12

55 [0056] The methodology used in Examples 1-4 was repeated in these Examples using the polymer compositions reported in Table 7. The polymer composition was vulcanized at 180°C for a period of 12, 12, 13 and 13 minutes, respectively, for each of Examples 9-12.

5 [0057] As will be apparent to those of skill in the art, the polymer composition of Examples 9 and 11 contained no special additive. Accordingly, Examples 9 and 11 are provided for comparison purposes only and are outside the scope of the present invention. As will be further apparent to those of skill in the art, Examples 9 and 10 relate to a vulcanizate derived from a hydrogenated nitrite butadiene polymer whereas those of Examples 11 and 12 relate to a vulcanizate derived from a hydrogenated acrylonitrile, butadiene, unsaturated carboxylic acid ester terpolymer.

[0058] Various physical properties of the vulcanizates were determined as described in Examples 1-4. These properties are reported in Table 8 for Examples 9 and 10, and in Table 9 for Examples 11 and 12.

10 [0059] The properties of the vulcanizates reported in Tables 8 and 9 clearly illustrate the superiority of the hot air aging characteristics of the vulcanizates of Examples 10 and 12 (special additive used) when compared to the vulcanizate of Examples 9 and 11 (special additive not used), respectively. This translates into significant practical advantages in many of the conventional applications of the vulcanizates.

EXAMPLES 13-19

15 [0060] The methodology used in Examples 1-4 was repeated in these Examples using the polymer compositions reported in Table 10.

[0061] As will be apparent to those of skill in the art, the polymer composition of Example 19 contained no special additive. Accordingly, Example 19 is provided for comparison purposes only and is outside the scope of the present invention.

20 [0062] Various physical properties of the vulcanizates were determined as described in Examples 1-4. These properties are reported in Tables 11 and 12, and are illustrated in the accompanying Figure.

[0063] The properties of the vulcanizates reported in Tables 8 and 9 clearly illustrate the superiority of the hot air aging characteristics of the vulcanizates of Examples 13-18 (special additive used) when compared to the vulcanizate of Example 19 (special additive not used), respectively. The accompanying Figure is particularly instructive in showing 25 the significant relative improvement in the time needed for the aged vulcanizate to reach 100% elongation at break under the test conditions.

30 [0064] Additionally, these results illustrate the synergistic benefit of using a polycarbodiimide as an adjunct to the special additive. In this regard, reference can be made to a comparison of the properties for Example 13 with those of Examples 14 and 15, and to a comparison of the properties for Example 16 with those of Examples 17 and 18, particularly at longer aging periods. This translates into significant practical advantages in many of the conventional applications of the vulcanizates.

EXAMPLES 20-21

35 [0065] The methodology used in Examples 1-4 was repeated in these Examples using the polymer compositions reported in Table 13. The polymer composition was vulcanized at 180°C for a period of 17 minutes in each Example.

[0066] As will be apparent to those of skill in the art, the polymer composition of Example 20 contained no special additive. Accordingly, Example 20 is provided for comparison purposes only and is outside the scope of the present invention. As will be further apparent to those of skill in the art, Examples 20 and 21 relate to a vulcanizate derived from 40 an ethylene vinyl acetate copolymer.

[0067] Various physical properties of the vulcanizates were determined as described in Examples 1-4. These properties are reported in Table 14.

[0068] The properties of the vulcanizates reported in Table 14 clearly illustrates the superiority of the hot air aging characteristics of the vulcanizates of Example 21 (special additive used) when compared to the vulcanizate of Examples 20 (special additive not used). This translates into significant practical advantages in many of the conventional 45 applications of the vulcanizates.

Table 1

Ingredient	Example			
	1	2	3	4
Natural Rubber	100	100	100	100
Naugard™ 445	1.1	1.1	1.1	1.1
Vulkanox™ ZMB-2/C5 (ZMMBI)	0.4	0.4	0.4	0.4
Dynamar™ RC-5251Q	-	5	-	5

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Table 1 (continued)

Ingredient	Example			
	1	2	3	4
Maglite™ D	3	3	3	3
Stearic Acid, Emersol™ 132 NF	3	3	3	3
Zinc Oxide	5	5	5	5
Carbon Black, N660 Sterling-V	50	50	50	50
Sunpar™ 2280	10	10	10	10
Diak #7	1.5	1.5	-	-
Vulcup 40KE	3.5	3.5	-	-
Sulfasan DTDM	-	-	2	2
Sulfur	-	-	0.3	0.3
Vulkacit Thiuram/C (D)	-	-	2	2

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Table 2

Physical Properties	Example		% Change	
	1	2	1	2
Unaged				
Elongation at break	325	360	-	-
Hardness, Shore A	48	48		
Aged 4h @ 110°C				
Elongation at break	380	385	16.9	6.9
Hardness, Shore A	53	53		
Aged 240h @ 110°C				
Elongation at break	245	295	-24.6	-18.1
Hardness, Shore A	52	52		
Aged 504h @ 110°C				
Elongation at break	135	260	-58.5	-27.8
Hardness, Shore A	52	47		
Aged 1008h @ 110°C				
Elongation at break	2	200	-99.4	-44.4
Hardness, Shore A	82	46		
Aged 240h @ 120°C				
Elongation at break	190	320	-41.5	-11.1
Hardness, Shore A	46	45		
Aged 504h @ 120°C				
Elongation at break	1	150	-99.7	-58.3
Hardness, Shore A	76	40		

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Table 2 (continued)

Physical Properties	Example		% Change	
	1	2	1	2
Aged 1008h @ 120°C				
Elongation at break	1	70	-99.7	-80.6
Hardness, Shore A	78	54		

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Table 3

Physical Properties	Example		% Change	
	3	4	3	4
Unaged				
Elongation at break	220	230	-	-
Hardness, Shore A	60	60		
Aged 4h @ 110°C				
Elongation at break	200	220	-9.1	-4.3
Hardness, Shore A	65	63		
Aged 240h @ 110°C				
Elongation at break	120	130	-45.5	-43.5
Hardness, Shore A	67	67		
Aged 504h @ 110°C				
Elongation at break	5	80	-97.7	-65.2
Hardness, Shore A	70	66		
Aged 1008h @ 110°C				
Elongation at break	2	50	-99.1	-78.3
Hardness, Shore A	86	73		
Aged 240h @ 120°C				
Elongation at break	40	115	-81.8	-50
Hardness, Shore A	66	62		
Aged 504h @ 120°C				
Elongation at break	1	40	-99.5	-82.6
Hardness, Shore A	72	71		

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Table 4

Ingredient	Example			
	5	6	7	8
Buna™ EP T2070	100	100	-	-

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Table 4 (continued)

Ingredient	Example			
	5	6	7	8
Buna™ EP T6850	-	-	100	100
Dynamar™ RC-5251Q	-	5	-	5
Maglite™ D	3	3	3	3
Naugard™ 445	1.1	1.1	1.1	1.1
Stearic Acid, Emersol™ 132 NF	1	1	1.5	1.5
Vulkanox™ ZMB-2/C5 (ZMMBI)	0.4	0.4	0.4	0.4
Zinc Oxide	3	3	5	5
Carbon Black, N660 Sterling-V	50	50	50	50
Sunpar™ 2280	10	10	10	10
Diak #7	1.5	1.5	1.5	1.5
Vulcup 40KE	7.5	7.5	3.5	3.5

Table 5

	Example		% Change	
	5	6	5	6
Physical Properties				
Unaged				
Elongation at break	280	250	-	-
Hardness, Shore A	64	66		
Aged 240h @ 160°C				
Elongation at break	335	360	19.6	44
Hardness, Shore A	71	75		
Aged 504h @ 160°C				
Elongation at break	285	345	1.8	38
Hardness, Shore A	73	72		
Aged 1008h @ 160°C				
Elongation at break	85	190	-69.6	-24
Hardness, Shore A	73	76		

Table 6

	Example		% Change	
	7	8	7	8
Physical Properties				
Unaged				
Elongation at break	380	350	-	-
Hardness, Shore A	61	59		

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Table 6 (continued)

	Example		% Change	
	7	8	7	8
5	Aged 240h @ 160°C			
10	Elongation at break	210	270	-44.7
15	Hardness, Shore A	75	70	-22.9
20	Aged 504h @ 160°C			
25	Elongation at break	60	160	-84.2
30	Hardness, Shore A	75	75	-54.3
35	Aged 1008h @ 160°C			
40	Elongation at break	1	30	-99.7
45	Hardness, Shore A	94	84	-91.4

Table 7

Ingredient	Example			
	9	10	11	12
Therban™ A3907	100	100	-	-
Therban™ VP KA 8798*	-	-	100	100
Dynamar™ RC-5251Q	-	5	-	5
Maglite™ D	-	-	3	3
Vulcanox™ OCD/SG (ODPA)	1	1	1	1
Vulcanox™ ZMB-2/C5 (ZMMBI)	0.4	0.4	0.4	0.4
Zinc Oxide	3	3	3	3
Carbon Black, N660 Sterling-V	50	50	50	50
Plasthall TOTM	5	5	5	5
Diak #7	1.5	1.5	1.5	1.5
Vulcup 40KE	6.5	6.5	7.5	7.5

*hydrogenated acrylonitrile, butadiene, unsaturated carboxylic acid ester terpolymer

Table 8

	Example		% Change	
	9	10	9	10
50	Physical Properties			
55	Unaged			
	Elongation at break	275	285	-
	Hardness, Shore A	70	72	-
	Aged 24h @ 170°C			

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Table 8 (continued)

		Example	% Change	
5	Physical Properties	9	10	9 10
10	Elongation at break	235	300	-14.5 13.2
	Hardness, Shore A	74	75	
15	Aged 48h @ 170°C			
20	Elongation at break	210	290	-23.6 9.4
	Hardness, Shore A	75	79	
25	Aged 72h @ 170°C			
30	Elongation at break	185	290	-32.7 9.4
	Hardness, Shore A	76	78	
35	Aged 96h @ 170°C			
40	Elongation at break	145	295	-47.3 11.3
	Hardness, Shore A	79	78	
45	Aged 168h @ 170°C			
50	Elongation at break	25	160	-90.9 -40
	Hardness, Shore A	88	81	
55	Aged 240h @ 170°C			
	Elongation at break	40	165	-85.5 -38
	Hardness, Shore A	86	82	

Table 9

		Example	% Change	
35	Physical Properties	11	12	11 12
40	Unaged			
	Elongation at break	220	235	-
	Hardness, Shore A	62	65	
45	Aged 120h @ 160°C			
50	Elongation at break	210	290	-4.5 23.4
	Hardness, Shore A	76	77	
55	Aged 240h @ 160°C			
	Elongation at break	145	285	-34.1 21.3
	Hardness, Shore A	78	78	
	Aged 360h @ 160°C			
	Elongation at break	125	240	-43.2 2.1
	Hardness, Shore A	82	85	
	Aged 480h @ 160°C			
	Elongation at break	80	230	-63.6 -2.1

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Table 9 (continued)

	Example		% Change	
	11	12	11	12
Physical Properties				
Hardness, Shore A	86	83		

Table 10

Ingredient	Example						
	13	14	15	16	17	18	19
Therban™	100	100	100	100	100	100	100
Dynamar™ RC-5251Q	2.5	2.5	2.5	5	5	5	-
Rhenogran™ P-50	-	5	10	-	5	10	-
Vulcanox™ OCD/SG (ODPA)	1	1	1	1	1	1	1
Vulcanox™ ZMB-2/C5 (ZMMBI)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Zinc Oxide	3	3	3	3	3	3	3
Carbon Black, N660 Sterling-V	50	50	50	50	50	50	50
Plasthall TOTM	5	5	5	5	5	5	5
Diak #7	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Vulcup 40KE	6.5	6.5	6.5	6.5	6.5	6.5	6.5

Table 11

	Example						
	13	14	15	16	17	18	19
Physical Properties							
Unaged							
Ultimate elongation	255	275	220	265	270	290	285
Hardness, Shore A	69	68	69	70	68	68	70
Aged 72h @ 160°C	285	270	240	300	310	320	195
Ultimate elongation	76	74	75	78	76	75	76
Hardness, Shore A							
Aged 144h @ 160°C	280	260	240	310	290	310	170
Ultimate elongation	78	74	74	74	75	76	77
Hardness, Shore A							
Aged 216h @ 160°C	275	290	255	315	330	330	115
Ultimate elongation	76	77	70	79	76	75	78
Hardness, Shore A							
Aged 336h @ 160°C	90	230	240	215	285	325	35
Ultimate elongation	84	78	81	83	81	79	87

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Table 11 (continued)

		Example						
Physical Properties		13	14	15	16	17	18	19
	Hardness, Shore A							
	Aged 504h @ 160°C	20	95	140	55	180	265	5
	Ultimate elongation	81	77	77	76	76	76	88
	Hardness, Shore A							
	Aged 672h @ 150°C	10	45	125	25	100	200	1
	Ultimate elongation	91	86	85	88	85	84	92
	Hardness, Shore A							

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Table 12

		Example						
Physical Properties		13	14	15	16	17	18	19
	Unaged							
	Ultimate elongation	255	275	220	265	270	290	285
	Hardness, Shore A	69	68	69	70	68	68	70
	Aged 168h @ 150°C	20.4	20.6	17.4	19.8	20.9	20.8	25.0
	Ultimate tensile (MPa)	290	260	240	300	285	285	210
	Ultimate elongation	78	74	74	77	76	73	77
	Hardness, Shore A							
	Aged 336h @ 150°C	16.5	17.5	16.0	16.1	17.6	18.6	17.4
	Ultimate tensile (MPa)	230	275	220	300	320	315	80
	Ultimate elongation	81	79	78	79	78	78	82
	Hardness, Shore A							
	Aged 504h @ 150°C	16.6	17.3	16.0	15.8	17.3	18.6	13.4
	Ultimate tensile (MPa)	205	235	200	235	290	290	35
	Ultimate elongation	75	66	71	76	73	73	80
	Hardness, Shore A							
	Aged 1008h @ 150°C	5.1	14.3	13.5	12.4	13.7	14.6	13.3
	Ultimate tensile (MPa)	25	155	160	105	245	270	0
	Ultimate elongation	85	78	79	83	82	80	90
	Hardness, Shore A							
	Aged 1512h @ 150°C	4.4	5.8	9.4	7.6	10.8	12.3	3.8
	Ultimate tensile (MPa)	1	25	65	30	80	125	1
	Ultimate elongation	92	84	82	84	83	81	86
	Hardness, Shore A							
	Aged 2016h @ 150°C	0.5	5.9	8.8	5.9	8.8	10.8	0.1

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Table 12 (continued)

Physical Properties	Example						
	13	14	15	16	17	18	19
Ultimate tensile (MPa)	0	15	45	45	50	75	0
Ultimate elongation	89	87	84	82	86	80	88
Hardness, Shore A							

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Table 13

Ingredient	Example	
	20	21
Levapren™ 500HV (KA8608)	100	100
Armeen™ 18D	2	2
Dynamar™ RC-5251Q	-	5
Maglite™ D	3	3
Naugard™ 445	1.1	1.1
Stearic acid, Emersol™ 132 NF	1	1
Vulkanox™ ZMB-2/C5 (ZMMBI)	0.4	0.4
Zinc Oxide	3	3
Carbon Black, N660 Sterling-V	50	50
Plasthall TOTM	5	5
Diak #7	1.5	1.5
Vulcup 40KE	7.5	7.5

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Table 14

Physical Properties	Example		% Change	
	20	21	20	21
Unaged				
Elongation at break	190	190	-	-
Hardness, Shore A	67	70		
Aged 240h @ 160°C				
Elongation at break	220	310	15.8	63.2
Hardness, Shore A	80	84		
Aged 504h @ 160°C				
Elongation at break	180	210	-5.3	10.5
Hardness, Shore A	80	86		
Aged 1008h @ 160°C				

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Table 14 (continued)

	Example		% Change	
	20	21	20	21
Physical Properties				
Elongation at break	75	100	-60.5	-47.4
Hardness, Shore A	84	87		

[0069] The publications, patents and/or patent applications referred to in this specification are for U.S. patent practice incorporated by reference in their entirety to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated by reference in its entirety for U.S. patent practice.

Claims

15 1. A polymer composition comprising:

a polymer having a main polymer chain derived from: (i) at least 30% by weight of a first monomer which introduces at least one of a secondary carbon and a tertiary carbon to the main polymer chain, and (ii) in the range of from 0 to 70% by weight of at least one other monomer; and

20 a salt of a strong base and a weak acid, the salt comprising a metal selected from Group 1 of the Periodic Table of Elements (according to IUPAC 1985).

25 2. The polymer composition defined in claim 1, further comprising a polycarbodiimide.

3. The polymer composition defined in any one of claims 1-2, further comprising a filler.

4. The polymer composition defined in claim 3, wherein the filler is selected from the group consisting of group carbon black, clay, titanium dioxide, silica fillers, talc and mixtures thereof.

30 5. The polymer composition defined in any one of claims 1-4, wherein the polymer comprises an elastomer.

6. The polymer composition defined 5, wherein the elastomer is selected from the group consisting of ethylene-propylene copolymer, ethylene-propylene-non conjugated diene terpolymer, ethylene vinyl acetate copolymer, unsaturated nitrile/conjugated diene copolymer, hydrogenated unsaturated nitrile/conjugated diene copolymer, unsaturated nitrile/conjugated diene/ethylenically unsaturated monomer terpolymer, hydrogenated unsaturated nitrile/conjugated diene/ethylenically unsaturated monomer terpolymer, styrene/conjugated diene copolymer, hydrogenated styrene/conjugated diene copolymer, polyisoprene, natural rubber, polybutadiene and mixtures thereof.

40 7. The polymer composition defined in any one of claims 1-6, wherein the salt is selected from the group consisting of potassium carbonate, sodium carbonate, sodium or potassium salts of C₁ to C₅₀-mono, di or poly carboxylic acids, sodium phosphate, potassium phosphate and mixtures thereof.

45 8. The polymer composition defined in any one of claims 1-6, wherein the salt is selected from the group consisting of sodium carbonate, sodium stearate and mixtures thereof.

9. The polymer composition defined in any one of claims 1-8, wherein the salt is present in an amount in the range of from 0.5 to 50 parts by weight.

50 10. The polymer composition defined in any one of claims 1-8, wherein the salt is present in an amount in the range of from 1 to 20 parts by weight.

11. The polymer composition defined in any one of claims 1-10, further comprising a vulcanization system.

55 12. The polymer composition defined in claim 11, wherein the vulcanization system is selected from the group consisting of sulfur, a sulfur donor cure system and a peroxide compound.

13. A process for producing a polymer vulcanizate comprising the steps of:

5 (i) admixing the polymer composition defined in any one of claims 1-10 with a vulcanization system to produce a curable composition; and
(ii) vulcanizing the curable composition to produce the polymer vulcanizate.

14. The process defined in claim 13, further comprising a vulcanization system.

15. The process defined in claim 14, wherein the vulcanization system is selected from the group consisting of sulfur, 10 a sulfur donor cure system and a peroxide compound.

16. A method for improving the hot air aging characteristics of a polymer comprising the steps of:

15 admixing: (A) a polymer having a main polymer chain derived from: (i) at least 30% by weight of a first monomer which introduces at least one of a secondary carbon and a tertiary carbon to the main polymer chain, and (ii) in the range of from 0 to 70% by weight of at least one other monomer; and (B) a salt of a strong base and a weak acid, the salt comprising a metal selected from Group 1 of the Periodic Table of Elements (according to IUPAC 1985) to provide a polymer composition; and
20 vulcanizing the polymer composition.

17. The method defined in claim 16, wherein the polymer composition further comprises a polycarbodiimide.

18. The method defined in any one of claims 16-17, wherein the polymer composition further comprises a filler.

25 19. The method defined in claim 18, wherein the filler is selected from the group consisting of carbon black, clay, titanium dioxide, silica fillers, talc and mixtures thereof.

20 20. The method defined in any one of claims 16-19, wherein the polymer comprises an elastomer.

25 21. The method defined in 20, wherein the elastomer is selected from the group consisting of ethylene-propylene copolymer, ethylene-propylene-non conjugated diene terpolymer, ethylene vinyl acetate copolymer, unsaturated nitrile/conjugated diene copolymer, hydrogenated unsaturated nitrile/conjugated diene copolymer, unsaturated nitrile/conjugated diene/ethylenically unsaturated monomer terpolymer, hydrogenated unsaturated nitrile/conjugated diene/ethylenically unsaturated monomer terpolymer, styrene/conjugated diene copolymer, hydrogenated 35 styrene/conjugated diene copolymer, polyisoprene, natural rubber, polybutadiene and mixtures thereof.

22. The method defined in any one of claims 16-21, wherein the salt is selected from the group consisting of potassium 40 carbonate, sodium carbonate, sodium or potassium salts of C₁ to C₅₀-mono, di or poly carboxylic acids, sodium phosphate, potassium phosphate and mixtures thereof.

23. The method defined in any one of claims 16-21, wherein the salt is selected from the group consisting of sodium 45 carbonate, sodium stearate and mixtures thereof.

24. The method defined in any one of claims 16-23, wherein the salt is present in an amount in the range of from 0.5 to 50 parts by weight.

25. The method defined in any one of claims 16-23, wherein the salt is present in an amount in the range of from 1 to 55 20 parts by weight.

26. The method defined in any one of claims 16-25, the polymer composition further comprises a vulcanization system.

27. The method defined in claim 26, wherein the vulcanization system is selected from the group consisting of sulfur, a sulfur donor cure system and a peroxide compound.

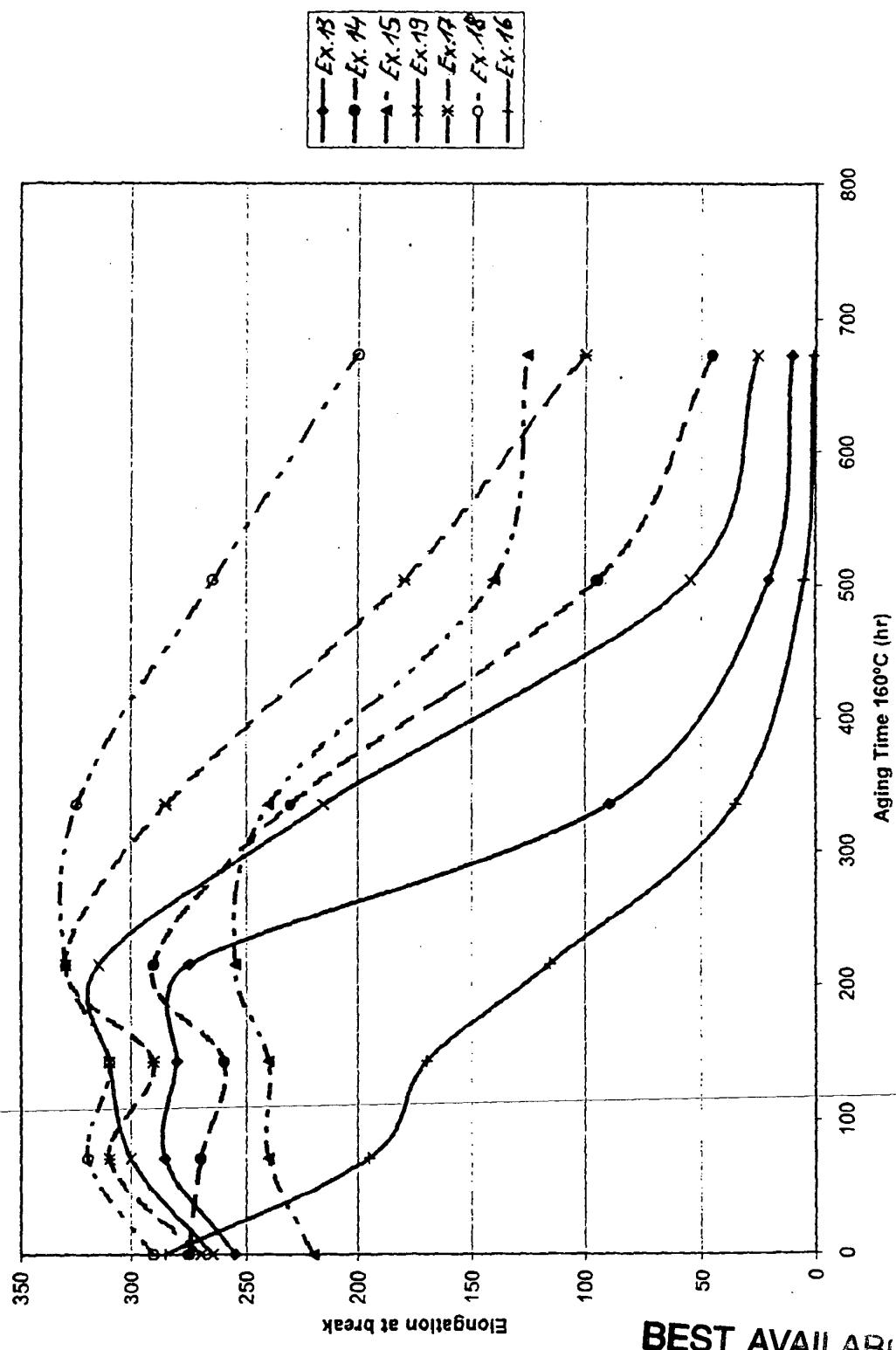


Fig. 1

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.)
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 09, 30 September 1997 (1997-09-30) & JP 09 137000 A (NIPPON ZEON CO LTD), 27 May 1997 (1997-05-27) * abstract *	1	C08L9/00 C08J3/24 C08K3/00 C08K5/098
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 03, 31 March 1997 (1997-03-31) & JP 08 311289 A (JAPAN SYNTHETIC RUBBER CO LTD), 26 November 1996 (1996-11-26) * abstract *	1	
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
MUNICH		13 November 2000	Iraegui Retolaza, E
CATEGORY OF CITED DOCUMENTS			
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EUROPEAN SEARCH REPORT

Application Number
EP 00 11 7297

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 04, 30 April 1996 (1996-04-30) & JP 07 331035 A (DENKI KAGAKU KOGYO KK), 19 December 1995 (1995-12-19) * abstract *	1	
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X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 03, 31 March 1997 (1997-03-31) & JP 08 302079 A (CHISSO CORP), 19 November 1996 (1996-11-19) * abstract *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
X	DATABASE WPI Derwent Publications Ltd., London, GB; AN 1994-198963 XP002152679 & SU 1 807 997 A, 7 April 1993 (1993-04-07) * abstract *	1	
		-/-	
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
MUNICH	13 November 2000	Iraegui Ret Laza, E	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.)						
X	<p>DATABASE WPI Derwent Publications Ltd., London, GB; AN 1994-240491 XP002152680 & SU 1 815 268 A, 15 May 1993 (1993-05-15) * abstract *</p>	1							
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<p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 34%;">Examiner</td> </tr> <tr> <td>MUNICH</td> <td>13 November 2000</td> <td>Iraegui Retolaza, E</td> </tr> </table>				Place of search	Date of completion of the search	Examiner	MUNICH	13 November 2000	Iraegui Retolaza, E
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MUNICH	13 November 2000	Iraegui Retolaza, E							
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